Hierarchically Self-Organized Magnetic Nanostructures

Scientific Achievement

Block copolymer films are powerful templating agents due to their tunable domain size and shape. A challenging problem in block copolymer research is to gain control over microdomain location, orientation, and defect density via the application of external fields. The goal is to achieve arbitrary long-range-ordered systems. We report a novel methodology to align self-organized cylindrical polymer domains over macroscopic length scales. Electron beam lithography is used to create channels on a silicon nitride substrate. These troughs guide the self-assembly of poly(styrene-*block*-ethylene-*alt*-propylene), PS-b-PEP, cylindrical-phase diblock copolymer thin films.

Such striped polymer films can be used as a scaffold for the nanoscale organization of inorganic materials. Of specific interest is the interaction of surfactant-mediated colloidal nanoparticles and diblock copolymer films because the nanocrystal capping molecules can be tailored to exhibit preference for one of the polymer blocks. We find inconsistent selectivity with oleic acid- and alkanethiol-capped nanoparticles adsorbed on cylindrical poly(styrene-*block*-methyl methacrylate), PS-*b*-PMMA, thin films. However, exposure to ultraviolet irradiation removes the surface PMMA domains and produces a striped morphology that exhibits remarkably high selectivity (~99%) for magnetic FePt nanoparticle adsorption.

Significance

We have developed a novel method to align nanoscale cylindrical polymeric domains in confined geometries over macroscopic length scales. The flexibility of the copolymer enables it to smooth over defects created in the etching process, effectively healing potential sources of disorder. Thus, this hybrid directed self-assembly technique is a promising bridge between the parallel self-organization of molecules and the structural control of lithography technology. Ramifications of this work extend to potential future bit-patterned magnetic storage media. However, it is general to all surfactant-mediated nanoparticles, suggesting possible applications in the templating of electronic, biological, and catalytic systems. Incorporation of bio-inspired materials will broaden the scope of these studies work in the future. This work has been published in *Nano Letters*, **4**, 273 (2004) and *Langmuir*, **20**, 5091 (2004). These two publications have already generated 33 citations. This work has been published in *Adv. Mater.*, **17**, 2446 (2005) and in a review article in *J. Mater. Chem.*, **15**, 4189 (2005).

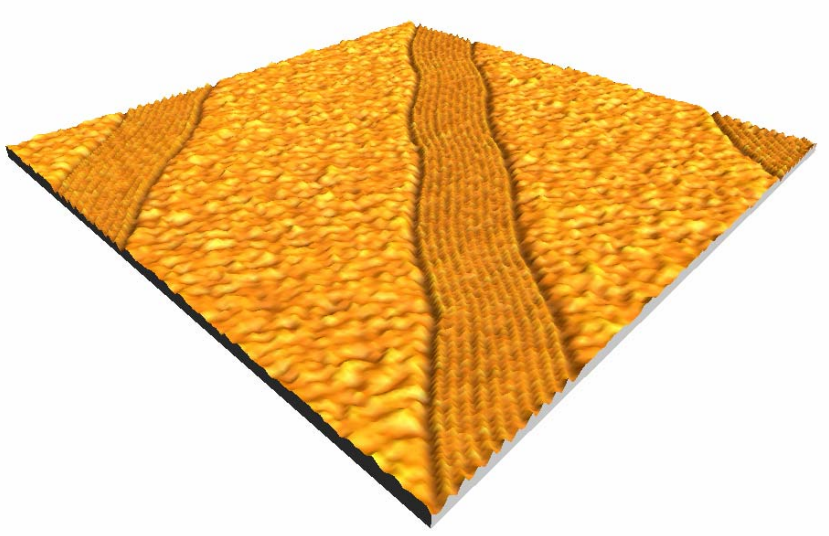
Performers

S.B. Darling, S.D. Bader (ANL-MSD)

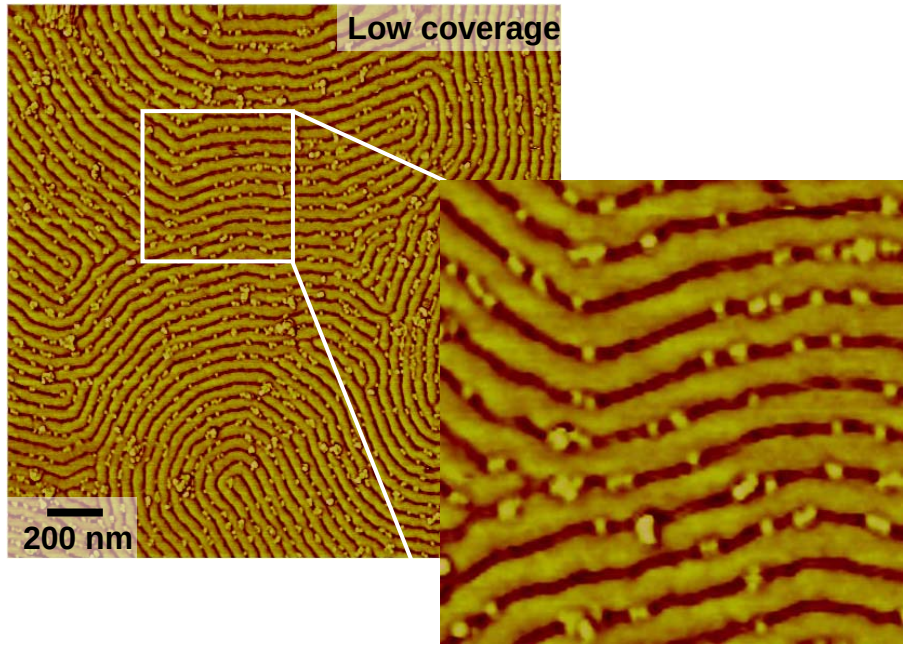
N.A. Yufa, S.J. Sibener (University of Chicago)

Hierarchically Self-Organized Magnetic Nanostructures

Top-down and bottom-up methodologies are merged in a hierarchical manner to achieve unprecedented control over the alignment of self-organized polymer stripe domains, which in turn can template the adsorption of functional nanomaterials



Directed self-assembly of aligned diblock copolymer domains



Selective decoration of a UV-modified polymeric template with magnetic nanoparticles

Seth B. Darling
Samuel D. Bader

Materials Science Division
ARGONNE NATIONAL LABORATORY

N.A. Yufa (UC Physics)
S.J. Sibener (UC Chemistry)